

# Emergency re-admissions to hospital due to adverse drug reactions within 1 year of the index admission

Emma C. Davies,<sup>1,2</sup> Christopher F. Green,<sup>3</sup> David R. Mottram,<sup>2</sup>  
Philip H. Rowe<sup>2</sup> & Munir Pirmohamed<sup>4</sup>

<sup>1</sup>The Royal Liverpool and Broadgreen University Hospitals Trust, Liverpool L7 8XP; <sup>2</sup>School of Pharmacy and Biomolecular sciences, Liverpool John Moores University, Liverpool L3 3AF; <sup>3</sup>Countess of Chester NHS Foundation Trust, Countess of Chester Health Park, Chester, CH2 1UL and <sup>4</sup>Department of Pharmacology and Therapeutics, The University of Liverpool, Liverpool L69 3GE, UK

## WHAT IS ALREADY KNOWN ABOUT THIS SUBJECT

ADRs in hospital patients are a significant burden, though how often ADRs cause re-admission to hospital has not been well documented in the literature.

## WHAT THIS STUDY ADDS

- One fifth of patients re-admitted to hospital within 1 year of discharge from their index admission were re-admitted due to an adverse drug reaction.
- Admission to a medical ward, elderly age and prescription of anti-platelet agents or diuretics were identified as risk factors for re-admission due to ADRs.
- Since up to 50% of these reactions were possibly avoidable, better methods of medication review in both hospital and primary care, in conjunction with a clinical review, are needed to enable improved prescribing practices that will be essential for improving the benefit-harm balance of medicines.

## AIM

The proportion of re-admissions to hospital caused by ADRs is poorly documented in the UK. The aim of this study was to evaluate the impact of ADRs on re-admission to hospital after a period as an inpatient.

## METHODS

One thousand patients consecutively admitted to 12 wards were included. All subsequent admissions for this cohort within 1 year of discharge from the index admission were retrospectively reviewed.

## RESULTS

Of the 1000 patients included, 403 (40.3%, 95% CI 39.1, 45.4%) were re-admitted within 1 year. Complete data were available for 290 (70.2%) re-admitted patients, with an ADR contributing to admission in 60 (20.8%, 95% CI 16.4, 25.6%) patients. Presence of an ADR in the index admission did not predict for an ADR-related re-admission (10.5% vs. 7.2%,  $P = 0.25$ ), or re-admission overall (47.2% vs. 41.2%,  $P = 0.15$ ). The implicated drug was commenced in the index admission in 33/148 (22.3%) instances, with 37/148 (25%) commenced elsewhere since the index admission. Increasing age and an index admission in a medical ward were associated with a higher incidence of re-admission ADR. The most frequent causative drugs were anti-platelets and loop diuretics, with bleeding and renal impairment the most frequent ADRs. Over half (52/91, 57.1%) of the ADRs were judged to be definitely or possibly avoidable.

## CONCLUSIONS

One fifth of patients re-admitted to hospital within 1 year of discharge from their index admission are re-admitted due to an ADR. Our data highlight drug and patient groups where interventions are needed to reduce the incidence of ADRs leading to re-admission.

## Correspondence

Dr Emma C. Davies, c/o CRH Group, Liverpool School of Tropical Medicine, University of Liverpool, Pembroke Place, Liverpool L3 5QA, UK.  
Tel.: + 44 772 950 2403  
Fax: + 44 151 705 3329  
E-mail: edavies@liverpool.ac.uk

## Keywords

adverse drug reactions, hospitals, pharmacoepidemiology, re-admission

## Received

27 February 2010

## Accepted

4 June 2010

## Introduction

Studies from our research group have shown that 6.5% of hospital admissions are due to adverse drug reactions (ADRs) [1], and that almost 15% of UK patients experience an ADR during their admission [2]. However, little is known about re-admissions to hospitals due to ADRs.

There is a clearly a need to reduce re-admission rates to hospital, whether they are due to drugs or not. This is important in terms of patient care, and in relieving the burden on over-stretched hospitals. A recent news item highlighted that approximately 500 000 patients are re-admitted to UK hospitals every year [3]. There are many reasons for this including premature discharge because of pressure on beds, poor community support services, infections and poor treatment, which includes drugs causing adverse effects. For example, a German study from 2004 found that 37% of inpatients in internal medicine wards were re-admitted, mostly within 6 weeks of discharge. However ADR occurrence in previous admissions did not increase the risk of the ADRs in subsequent admissions [4]. Importantly, Dormann *et al.* noted that due to the high turnover of inpatients, ADRs caused by in-house therapy are not entirely distinct from community acquired ADRs [4]. Recurrent ADRs causing multiple admissions for the same patient were found to be increasing in an Australian study and were responsible for one third of ADR-related admissions [5].

In this study, we aimed to assess the rate of emergency re-admissions to hospital within 1 year of discharge from a hospital ward. The 1 year time period enabled the identification of ADRs which may not be immediately apparent following commencement of new medicines. As 28-day re-admission is an UK NHS performance indicator [6], this time period was also examined. This study aimed to distinguish ADRs that originated in hospital from those originating elsewhere and potentially identify which of these ADRs, and subsequent admissions, were preventable.

## Methods

The first 1000 patients admitted to 12 wards as part of a prospective study examining ADRs in hospital in-patients

[2] were included in the study. If they were re-admitted within 12 months of discharge from their initial (index) admission, the cause of their re-admission was recorded. As a secondary analysis, the re-admission rate within 28 days of discharge was also calculated. Data on whether or not the patients had an ADR during their index admission were obtained from the in-patient study [2]. Admission and discharge data were extracted from the hospital patient administration system (PAS) system with the assistance of the hospital audit department using InfoCom and Microsoft Access. A research pharmacist conducted a retrospective case note review examining the clinical information available for evidence of ADRs relating to re-admission. Data were collected manually and transferred to a Microsoft Access database. An ADR was defined according to Edwards & Aronson [7], with an ADR-related re-admission being defined as: 'an ADR, which is the reason for, or contributes to the admission to hospital of a patient in the defined cohort'. The reasons for index admission and subsequent re-admissions were recorded.

Suspected ADRs were analyzed for causality [8], avoidability [9], and suitability for reporting to the UK Regulator, the Medicines and Healthcare Regulatory Authority (MHRA) [10]. All ADRs were initially assessed by two investigators and any discrepancies were discussed before the appropriate classification of each ADR was finalized. The ADRs were also classified as Type A or Type B reactions according to the classification of Rawlins & Thompson [11].

Approval for the study was obtained from the Study Hospital Audit Department; Ethics Committee advice was sought and approval was not required. Statistical analysis was performed using StatsDirect version 2.6.2 and *P* values of <0.05 were interpreted as statistically significant.

## Results

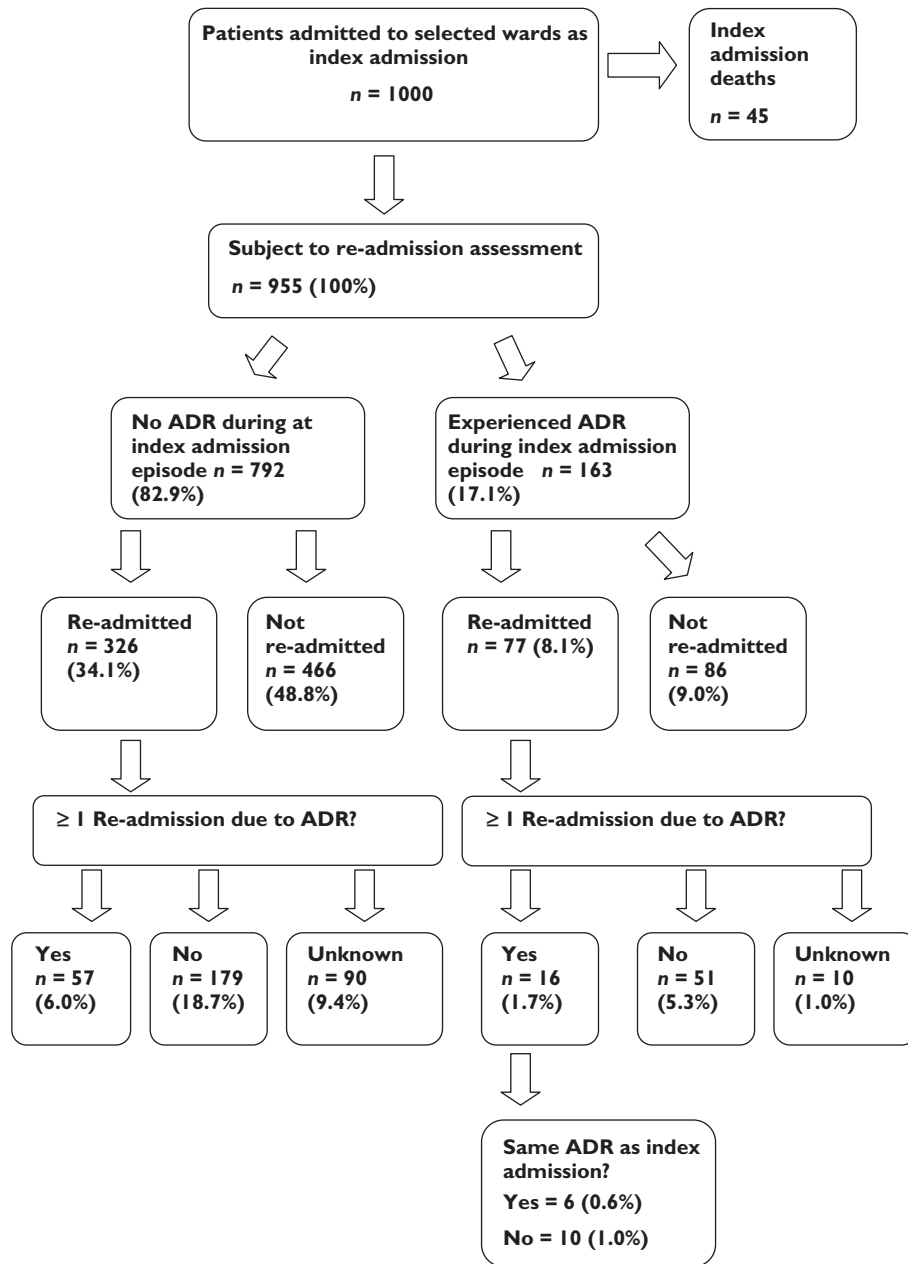
Of the 1000 patients included in the study, 403 patients (40.3%, 95% CI 39.1, 45.4%) were re-admitted to the hospital in the year following the index admission. The patients' demographic details are shown in Table 1.

Figure 1 shows ADR prevalence during admission and at re-admission for the 955 patients who were discharged from their index admission. Of the 403 re-admitted, 73

**Table 1**

Demographic data – Re-admitted vs. not re-admitted patients

Variable	Overall ( <i>n</i> = 955)	Re-admitted ( <i>n</i> = 403)	Not re-admitted ( <i>n</i> = 552)	<i>P</i> value (re-admitted vs. not re-admitted)
Age (years) [median, (Q1–Q3)]	62 (42–76)	68 (47–79)	56 (39–74)	<0.0001
Male sex (%)	453 (47.4%)	199 (49.3%)	254 (46.1%)	>0.3
Number of medical patients at index admission (medical or surgical) (%)	679 (71.1%)	316 (78.4%)	363 (65.8%)	<0.0001

**Figure 1**

Flow chart showing numbers of patients with ADRs during index admission and those re-admitted within 1 year of discharge from index admission

(18.1%) patients had at least one ADR-related re-admission. However, the outcome was unknown for 100 patients. If the patients with unknown outcomes are excluded, 73 of 303 (24.1%, 95% CI 19.6, 29.2%) patients had one or more ADR-related re-admissions within 1 year of discharge from the index admission.

A total of 950 readmission episodes were identified in the 403 patients who were re-admitted to hospital. Case-note data on 669 (70.4%) of these re-admission episodes were available. The median time to the first re-admission episode was 65 days [Quartile 1 (Q1) to Quartile 3 (Q3)

22–154 days]. The number of re-admission episodes for individual patients ranged from 1 to 28 [median 1 (Q1–Q3 1–3 readmissions)]. Complete data were available for 290 (70.2%) of the re-admitted patients, with an ADR contributing to admission in 60 (20.8%, 95% CI 16.4, 25.6%) patients. A total of 91 ADRs were identified in 73 patients, in 86 re-admissions. ADRs were directly responsible for admission in 67 of 669 assessable re-admissions (10.0%), and contributed to re-admission in 19 (2.8%) cases.

Patients re-admitted due to ADRs had a median age of 74 years (Q1–Q3, 61–82 years). A total of 30 of 403 males

**Table 2**

Reasons for readmission and ADRs

Reason for re-admission (within 1 year)	Number of re-admissions (n = 669)	ADR-related re-admission (n = 86)
Manifestation of same disease state as index admission	312 (46.6%)	25 (29.1%)
Manifestation of different disease state to index admission	333 (49.8%)	58 (67.4%)
Social issues	4 (0.6%)	1 (1.2%)
Other (e.g. rehabilitation)	1 (0.1%)	0 (0.0%)
Unknown reason for index admission	19 (2.8%)	2 (2.3%)

**Table 3**

ADRs linked with deaths

Adverse drug reaction	Number of associated patient deaths (n = 8)	Drugs (number of deaths)	Avoidability (definite, possible, unavoidable)
Renal impairment	4	Amiloride (1), atenolol (1), bumetanide (2), enalapril (1), furosemide (2), ramipril (2), spironolactone (1)	1 definite 2 possible 1 unavoidable
Gastro-intestinal bleeding	3	Aspirin (2), clopidogrel (1)	3 unavoidable
Torsades de pointes	1	Chlorpromazine (1), quetiapine (1)	1 unavoidable

(7.4%), and 43 of 451 (9.5%) females were re-admitted due to ADRs ( $\chi^2 = 1.17$ ,  $P > 0.1$ ). The median length of stay for the index admission was not significantly different between those re-admitted due to ADRs (10 days, Q1-Q3, 8–16 days) and those not re-admitted due to ADRs (9 days, Q1-Q3, 5–16 days). Experiencing an ADR during the index admission did not significantly increase the incidence of re-admission to hospital (77/163 (47.2%) vs. 326/792 (41.2%)  $\chi^2 = 2.05$ ,  $P = 0.15$ ), or re-admission ADR rate (16/163 (10.5%) vs. 57/792 (7.2%),  $\chi^2 = 1.31$ ,  $P = 0.25$ ). Of the 403 patients re-admitted during the year following the index admission, 56 (13.9%) died following the re-admission to hospital. The median length of stay for re-admissions directly resulting from ADRs was 8 days (Q1-Q3, 3–14 days). The reason for re-admission and number of ADRs identified for these re-admissions are shown in Table 2.

The majority of ADRs ( $n = 88$ , 97%) were Type A ADRs [11]. ADRs occurred despite prophylactic treatment in 19 (20%) of cases. These ADRs were bleeding (10), constipation (3), gastritis (2), *C. difficile* infection (1), fractures (1), gastric ulcer (1), and seizure (1). Drug–drug interactions contributed to 38 (42%) ADRs, of which 36 (95%) were pharmacodynamic drug–drug interactions. There were two pharmacokinetic interactions, both of which involved warfarin. One was with amiodarone, which resulted in an increase in the International Normalized Ratio (INR), while the other was with erythromycin, which caused an increased INR and epistaxis.

A total of 78 (86%) ADRs were reportable to the CHM/MHRA Yellow Card Scheme [10]. The majority of ADRs ( $n = 53$ , 58.2%) were classified as ‘definite’ or ‘probable’

ADRs, with 38 (41.8%) of ADRs classified as ‘possible’ using the Naranjo algorithm [8]. Over half of ADRs were classified as ‘definitely’ ( $n = 13$ , 14.3%) or ‘possibly’ ( $n = 39$ , 42.9%) avoidable, with 39 (42.9%) classified as ‘unavoidable’ [9]. Eight ADRs contributed to the death of the affected patient, one directly (Table 3).

A detailed description of the ADRs and their causative drugs is shown in Table 4. Anti-platelets and loop diuretics were the most common causative drug groups, with bleeding and renal impairment the most frequent ADRs.

A total of 64 different drugs, and 148 prescriptions contributed to ADRs. The drug implicated in causing the ADR had been started in a number of settings, with approximately 22% having been started during the index admission (Table 5).

For comparison, within 28 days of the index discharge, 121 patients (12.7%) were re-admitted. Complete data for these admissions were available for 100 (83%) patients, and 23 (23.0%, 95% CI 15.8, 32.2%) of these patients experienced an ADR-related re-admission in this time-period.

## Discussion

This study has shown that approximately one fifth of those patients re-admitted to hospital within 1 year of discharge are re-admitted due to a suspected ADR, and that approximately half of these ADRs are definitely or possibly avoidable. Our data are consistent with other studies which have shown that drug-related problems are a significant, and often avoidable, factor in re-admission [4, 5, 12, 13], despite

**Table 4**

Adverse drug reactions within 1 year of index discharge and causative drugs

Description of reaction	Number of reactions <i>n</i> = 91, (number of patients)	Causative drug (number of ADRs)
Bleeding	17 (13)	Aspirin (7); clopidogrel (5); warfarin (3); diclofenac, citalopram (2); alendronate, dalteparin, erythromycin, prednisolone (1)
Renal impairment	11 (8)	Furosemide, spironolactone (6); bumetanide, ramipril (5); digoxin (2); amiloride, atenolol, diclofenac, enalapril, metformin, telmisartan (1)
Constipation	8 (7)	Iron supplements (4); amitriptyline (3); phenytoin (2); citalopram, hyoscine butylbromide, morphine, tramadol (1)
Electrolyte disturbances	8 (7)	Calcitriol, furosemide (2); bumetanide, calcium supplements, citalopram, fludrocortisone, potassium supplements (1)
Hypoglycaemia	5 (4)	Biphasic isophane insulin (5)
<i>C. difficile</i> infection	4 (2)	Amoxicillin, lansoprazole (3); ceftriaxone, ciprofloxacin, clarithromycin, omeprazole (1)
Fall	4 (4)	Perindopril (2); amisulpiride, atenolol, bisoprolol, carbamazepine, co-amiloride, furosemide, lamotrigine (1)
Fracture	4 (4)	Prednisolone (4); fluticasone (3)
Seizures	3 (1)	Citalopram (3)
Anaemia	2 (2)	Aspirin, clopidogrel, diclofenac, prednisolone (1)
Gastritis	2 (2)	Aspirin, citalopram, prednisolone (1)
Increased INR	2 (2)	Warfarin (2); amiodarone (1)
Convulsive reaction	2 (1)	Trimethoprim (2)
Abdominal pain	1 (1)	Aspirin, diclofenac (1)
Anaphylaxis	1 (1)	Flucloxacillin (1)
Bradycardia	1 (1)	Bisoprolol (1)
Candidal infection	1 (1)	Mycophenolate, prednisolone(1)
Diarrhoea	1 (1)	Amoxicillin, cefalexin, ciprofloxacin (1)
Elevated LFTs	1 (1)	Atorvastatin (1)
Erythema nodosum	1 (1)	Azathioprine (1)
Flushing	1 (1)	Sulfasalazine (1)
Gastric ulcer	1 (1)	Aspirin, diclofenac (1)
Gout	1 (1)	Furosemide (1)
Hyperglycaemia	1 (1)	Olanzapine (1)
Hyperpyrexia	1 (1)	Trifluoperazine (1)
Neutropenic sepsis	1 (1)	Cancer chemotherapy agents (1)
Opioid dependence	1 (1)	Pethidine (1)
Rash	1 (1)	Flucloxacillin (1)

**Table 5**

Relation of prescription of causative drug to index admission

Description	ADR re-admission	
	Within 28 days: number of causative drug prescriptions <i>n</i> = 37, (%)	Within 1 year: number of causative drug prescriptions <i>n</i> = 148, (%)
Causative drug continued unchanged during the index admission	19 (51.4)	68 (45.9)
Causative drug was initiated during the index admission	11 (29.7)	33 (22.3)
Causative drug prescribed elsewhere/dose changed since the index admission	5 (13.5)	37 (25.0)
Causative drug had dose changed during the index admission	2 (5.4)	3 (2.0)
Unknown – Data regarding medicines use missing from patient case notes for index admission.	0 (0)	7 (4.7)

the fact the study designs, including time periods for re-admission, and definitions of drug-related problems, have varied between studies.

Approximately 13% of patients were re-admitted to the study hospital within a 28-day time period. Approximately 23% of these re-admissions were related to ADRs. The measurement of the rate of emergency re-admission to hospital

within 28 days of discharge from hospital is a NHS performance indicator, with previous data suggesting that approximately 5% of patients discharged from NHS hospitals are re-admitted as an emergency within 28 days [6]. The reason why the 28-day re-admission rate was higher in our hospital than the national average has not been examined in our study, but there are many possible explanations,

including the fact that the hospital serves a relatively elderly population from an inner city deprived area, and also because previous surveys may not have used robust methodology and therefore under-estimated the problem.

In common with the Australian study of ADR-related hospitalizations [5], increasing age was a significant factor in re-admissions overall, and particularly in re-admissions due to ADRs. No differences were found in re-admission or ADR rates with gender, despite the findings of previous work in the study hospital [1, 2] and in the ADR literature [14–17] which have suggested that ADR rates are higher in females. However, the totality of the evidence in the literature is not conclusive [18, 19], and a large study of emergency medical re-admissions in a UK hospital has actually shown the opposite, in that the overall re-admission risk at 12 months was significantly higher in males [20].

Being a medical patient, rather than a surgical patient, increased the risk of re-admission in our study. This may be a reflection of the increased number of medicines and co-morbidities seen in medical patients. The duration of length of stay during the index admission did not affect whether or not the patient experienced an ADR, while the presence of an ADR during the index admission also did not increase the risk of re-admission overall, or re-admission due to ADRs, in agreement with findings of Dormann *et al.* [4].

Bleeding was the most common ADR, with antiplatelets (aspirin and clopidogrel) amongst the most common causative drugs. Diuretics and anti-hypertensives also resulted in many ADRs. These findings match those of our admissions study [1]. In addition, Zhang *et al.* found that cardiovascular drugs were most frequently responsible for repeat ADR admissions [5]. Potentially avoidable deaths were associated with renal impairment with diuretics and anti-hypertensive medicines. The need for strategies to improve diuretic management was identified in an earlier study of hospital inpatients [2] as a key area for reducing ADR-related deaths. These recommendations are supported by this re-admissions study and by a recent systematic review of preventable ADR-related admissions [21]. In general, there is a need to improve the monitoring of drug therapy [22], but progress in this area is hampered by the lack of evidence of the type and frequency of monitoring.

One fifth of drugs causing re-admission were newly prescribed for the patient during the index admission, with the figure for 28-day re-admissions rising to almost one third of prescriptions. This highlights the importance of adequate follow-up of patients commenced on new medicines in hospital. Liaison between primary and secondary care and the individual patient is essential to ensure that medicines are continually reviewed for suitability in the patient's home environment [23, 24]. Indeed, all medicines, whether newly commenced, or long continued, need to be monitored.

This is the largest study of ADR-related re-admissions in the UK, but there are limitations of our findings. The admis-

sion to hospital used as the 'index admission' in this study was unlikely to have been the first hospital admission for most of the patients in this study, and it therefore serves as an arbitrary baseline assessment. As previously discussed, retrospective studies rely on the accuracy of the data recorded in the patient case notes [25]. In the study hospital, case notes are paper-based, often in several volumes, making case note tracking difficult and resulting in missing data. Extrapolations made to generate incidence rates for re-admissions in this study were thus made with caution. It is also important to note that emergency re-admissions to the study hospital alone and not to other hospitals were assessed.

Many of the events which will lead to hospital re-admission may have occurred irrespective of drug intake. Thus another limitation of our study is that we have not taken into account the attributable fraction caused by individual drugs. At an individual level, assessment of the aetiological fraction is not possible, and is further complicated by the fact that for most drug-related adverse reactions, there are no good data on which to estimate the aetiological fraction. Given these problems, by assessing each patient's case notes for each re-admission, and by conducting ADR causality assessments for each suspected reaction, we feel that we have presented data which acknowledge that alternative causes for these re-admissions may exist.

A valid criticism of studies and political targets, which assess re-admission as a health-related outcome, is that they fail to consider that avoiding re-admission is not a direct objective of hospital care and that some re-admissions are planned and some are unavoidable [26]. This study ensured that only emergency re-admissions were assessed, and that each ADR was assessed for avoidability in order to maintain objectivity when assessing the impact of ADRs on hospital re-admission.

In conclusion, one fifth of patients re-admitted to hospital within 1 year of discharge from their index admission are re-admitted due to an adverse drug reaction. This causes a significant burden on NHS resources due to avoidable ADRs. Aspirin and diuretics were among the most frequent causative drugs, and the elderly were the most at risk. Although our study is limited by the fact that it has only assessed harms, and not the known benefits of drugs, it nevertheless highlights the need to (i) effectively review patients' medicines both during the inpatient stay, and in primary care and (ii) develop strategies that continually assess the benefit-harm balance of medicines to ensure that this is maximized.

## Competing interests

Funding for this study was received from Liverpool John Moores University and the Royal Liverpool and Broadgreen University Hospitals Trust Research and Development

Fund. The sponsors had no role in the conception, design, conduct and writing-up of this study. MP is a member of the Commission on Human Medicines and Chairs its Pharmacovigilance Expert Advisory Group. The other authors have no competing interests. The views expressed in this article are entirely those of the authors, and do not represent the views of any organisations that they represent.

## REFERENCES

- Pirmohamed M, James S, Meakin S, Green C, Scott AK, Walley TJ, Farrar K, Park K, Breckenridge AM. Adverse drug reactions as a cause of admission to hospital: prospective analysis of 18 820 patients. *BMJ* 2004; 329: 15–9.
- Davies EC, Green CF, Taylor S, Williamson P, Mottram DR, Pirmohamed M. Adverse drug reactions in hospital in-patients: a prospective analysis of 3695 patient-episodes. *PLoS ONE* 2009; 4: e4439. doi:10.1371/journal.pone.0004439.
- Chapman J. 500 000 Hospital patients sent home too soon every year. Available at <http://www.dailymail.co.uk/news/article-1247568/500-000-hospital-patients-sent-home-soon.html> (last accessed 12 February 2010).
- Dormann H, Neubert A, Criegee-Rieck M, Egger T, Radespeiel-Troger M, Azaz-Livshits T, Levy M, Brune K, Hahn EG. Readmissions and adverse drug reactions in internal medicine: the economic impact. *Ann Intern Med* 2004; 255: 653–63.
- Zhang M, Holman DJ, Preen DB, Brameld K. Repeat adverse drug reactions causing hospitalization in older Australians: a population-based longitudinal study 1980–2003. *Br J Clin Pharmacol* 2007; 63: 163–70.
- NHS Executive. NHS Performance Indicators: July 2000. Technical Specifications – Readmission to hospital following discharge. Available at <http://www.performance.doh.gov.uk/nhsperformanceindicators/hlpi2000/c1139s.html> (last accessed 20 February 2010).
- Edwards IR, Aronson JK. Adverse drug reactions: definitions, diagnosis, and management. *Lancet* 2000; 356: 1255–9.
- Naranjo CA, Busto U, Sellers EM, Sandor P, Ruiz I, Roberts EA, Janecek E, Domecq C, Greenblatt DJ. A method for estimating the probability of adverse drug reactions. *Clin Pharmacol Ther* 1981; 30: 239–45.
- Hallas J, Harvald B, Gram LF, Grodum E, Brosen K, Haghfelt T, Damsbo N. Drug related hospital admissions: the role of definitions and intensity of data collection, and the possibility of prevention. *J Intern Med* 1990; 228: 83–90.
- Medicines and Healthcare Products Regulatory Authority. What to report. Available at [http://www.mhra.gov.uk/home/idcplg?IdcService=SS\\_GET\\_PAGE&nodel=750](http://www.mhra.gov.uk/home/idcplg?IdcService=SS_GET_PAGE&nodel=750) (last accessed 20 February 2010).
- Rawlins MD, Thompson JW. Pathogenesis of adverse drug reactions. In: *Textbook of Adverse Drug Reactions*, ed. Davies DM. Oxford: Oxford University Press, 1977; 10.
- Munshi SK, Lakhani D, Ageed A, Evans SN, Mackness E, Fancourt G. Readmissions of older people to acute medical units. *Nurs Older People* 2002; 14: 14–6.
- Chu L-W, Pei CKW. Risk factors for early emergency hospital readmission in elderly medical patients. *Gerontology* 1999; 45: 220–7.
- Routledge PA, O'Mahony MS, Woodhouse KW. Adverse drug reactions in elderly patients. *Br J Clin Pharmacol* 2003; 57: 121–6.
- Leach S, Roy SS. Adverse drug reactions: an investigation on an acute geriatric ward. *Age Ageing* 1986; 15: 241–6.
- Bowman L, Cardstedt BC, Hancock EF, Black CD. Adverse drug reaction (ADR) occurrence and evaluation in elderly inpatients. *Pharmacoepidemiol Drug Saf* 1996; 5: 9–18.
- Fattinger K, Roos M, Vergeres P, Holenstein C, Kind B, Masche U, Stocker DN, Barunshweig S, Kullak-Ublick GA, Galeazzi RL, Follath F, Gasser T, Meier PJ. Epidemiology of drug exposure and adverse drug reactions in two Swiss departments of internal medicine. *Br J Clin Pharmacol* 2000; 49: 158–67.
- Carbonin P, Pahor M, Bernabei R, Sgadari A. Is age an independent risk factor of adverse drug reactions in hospitalized medical patients. *J Am Geriatr Soc* 1991; 39: 1093–9.
- Montastruc J-L, Lapeyre-Mestre M, Bagheri H, Fooladi A. Gender differences in adverse drug reactions: analysis of spontaneous reports to a regional pharmacovigilance center in France. *Fund Clin Pharmacol* 2002; 16: 343–6.
- Lyratzopoulos G, Havelly D, Gemmell I, Cook GA. Factors influencing emergency medical readmission risk in a UK district general hospital: a prospective study. *BMC Emerg Med* 2005; 5: 1. doi: 10.1186/1471-227X-5-1.
- Howard RL, Avery AJ, Slavenburg S, Royal S, Pipe G, Lucassen P, Pirmohamed M. Which drugs cause preventable admissions to hospital? A systematic review. *Br J Clin Pharmacol* 2006; 63: 136–47.
- Pirmohamed M, Ferner RE. Monitoring drug treatment. *BMJ* 2003; 327: 1179–81.
- Forster AJ, Murff HJ, Peterson JF, Gandhi TK, Bates DW. The incidence and severity of adverse events affecting patients after discharge from the hospital. *Ann Intern Med* 2003; 138: 161–7.
- VanSuch M, Naessens JM, Stroebel RJ, Huddleston JM, Williams AR. Effect of discharge instructions on readmission of hospitalized patients with heart failure: do all of the Joint Commission on Accreditation of Healthcare Organizations heart failure core measures reflect better care? *Qual Saf Health Care* 2006; 15: 414–7.
- Cox JL, Zitner D, Courtney KD, MacDonald DL, Paterson G, Cochrane B, Mathers J, Merry H, Flowerdew G, Johnstone DE. Undocumented patient information: an impediment to quality of care. *Am J Med* 2003; 114: 211–6.
- Milne R, Clarke C. Can readmission rates be used as an outcome indicator? *BMJ* 1990; 301: 1139–40.